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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

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Title of the Invention: DOUBLE SIDE GRINDER AND WAFER CLAMP DEVICE THEREFOR

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ENCLOSED APPLICATION PARTS:

[X] Specification - Number of Pages 25

[X] Drawings - Number of Sheets 8

[X] Application Data Sheet

[X] Return Receipt Postcard

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[X] A check in the amount of $ 160.00 is enclosed to cover the Provisional Filing Fee.

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[X] No
[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ______

Respectfully submitted,

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DOUBLE SIDE GRINDER AND WAFER CLAMPING PADS THEREFOR

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to simultaneous double side grinding of semiconductor wafers and more particularly to a wafer clamping device of a double side grinder.

[0002] Simultaneous double side grinding is used to planarize semiconductor wafers prior to polishing. Double side grinding produces a very high degree of parallelism between the opposite broad faces of the wafer which is desirable in subsequent processing of the wafer. One type of double side grinder used for semiconductor wafers, manufactured by Koyo Machine Industries Co., Ltd., includes a pair of opposed grinding wheels, a drive ring and a wafer clamping device comprising hydrostatic pads. The wafer is positioned in a vertical orientation by the clamping device between the grinding wheels and is engaged on its periphery by the drive ring for driving the wafer in rotation at the same time the grinding wheels are rotated about a horizontal axis through their centers in operation of the grinder. The drive ring has a detent (or "coupon") that is capable of being received in a V-shaped orientation notch formed on the wafer to engage the drive ring with the wafer to drive rotation. The grinding wheels are positioned so that engagement with the wafer occurs in the lower center of the wafer. The clamping device includes opposed hydrostatic pads which engage the wafer on opposite sides to support the wafer in the grinder. Each pad has an opening sized and shaped to receiving a respective one of the grinding wheels through the pad and into engagement with the wafer. The edge of the pad openings and the periphery of the grinding wheels are closely spaced (e.g., on the order of three millimeters). The hydrostatic pads are made of a suitable rigid material such as metal and have on their faces which oppose the wafer several distinct recessed regions, or "pockets." Passages extending through

the pads have orifices in the pockets for delivering water into the pocket. The water is forced into the pockets under pressure during operation of the grinder so that water, and not the face of the pad actually contacts the wafers. The water supplies pressure for holding the wafer so that the wafer can turn relative to the pads without contacting the pads.

[0003] The grinding wheels each have three degrees of motion (in addition to the rotary motion of the wheels about their centers). The first is in translation along the axis of rotation of the wheels (called, "shift"), the second pivoting about a horizontal axis through the center of the wheel (called, "vertical tilt") and the third is pivoting about a vertical axis through the center of the wheel (called, "horizontal tilt"). The tilting motions are illustrated in Fig. 2 of the drawings. These motions permit the wheels to move into and out of engagement with the wafer, as well as to reorient for equalizing grinding pressure and minimize total thickness variation (TTV) of the ground wafer. When engaged with the wafer, the opposed grinding wheels define a clamping plane between them in which the wafer is held. Similarly, the hydrostatic pads define a clamping plane between them in which the wafer is held. The clamping plane of the grinding wheels and the clamping plane of the hydrostatic pads seldom coincide. Although alignment can be carried out the dynamics of the operation, as well as the effects of wear on the grinding wheels cause the planes to diverge. Alignment is time consuming and must be carried out so often as to make this a commercially impractical way of controlling process operation of the grinder.

[0004] The divergence of the clamping planes causes certain undesirable features in the nanotopology of the finished wafer (i.e., imperfections that are not removed by subsequent processing steps such as polishing and etching). For instance, shift of the grinding wheels and vertical tilt (away from the clamping plane defined by the

hydrostatic pads) cause a sharp bend in the wafer at its center between the uppermost points of the grinding wheels and the adjacent (radially opposed) points where the wafer is held by the hydrostatic pads. This sharp bend produces warp in the wafer which results in a distinct center mark feature on one of the surfaces of the wafer when measured on a nanometer scale ("nanotopology"). As another example, the combination of shift and horizontal tilt produces a sharp bend in the wafer to the sides of the grinding wheels which produces a ring around the center of the wafer (a "B-ring"). The center mark and B-ring for a wafer are illustrated in Fig. 1 of the drawings. Again, the bend in the wafer occurs between the peripheries of the grinding wheels and the adjacent edges of the hydrostatic pads. In both instances, the grinding wheels and the hydrostatic pads hold the wafers very rigidly in their respective clamping planes. For this reason the bend is exceedingly sharp at these locations, as is illustrated in Fig. 3 of the drawings. Thickness variation does not increase, but the stresses introduce warp into the wafer resulting in the surface features just described.

[0005] A general discussion regarding the introduction of warp (but not nanotopology features of center marks and B-rings) in a grinding process may be found in published European application No. 1 118 429.

DESCRIPTION OF ATTACHMENTS

[0006] 1. Appendix A is a summary of the problem addressed and solution proposed by the present invention.

[0007] 2. Appendix B (Double-Sided Grinding) is a report on finite element analyses done for double side grinding using the original hydrostatic pads and the hydrostatic pad of the present invention. The third sheet of the report (Original Pad: Spatially Uniform Clamping) is a visual finite element analysis of the clamping force applied to the wafer during grinding. The red coloring, and particularly the more solid red coloring, is indicative

of high clamping forces. It may be seen that the clamping force is applied all over the face of the wafer opposed by the hydrostatic pad. Moreover, the location of rigid clamping occurs in close proximity to the periphery of the grinding wheel. Sheet four (New Pad: Spatially Non-Uniform Clamping) shows the same analysis as for sheet three, but with the hydrostatic pads of the present invention. It may be seen that there are substantial areas of the wafer where very low clamping forces are evident. Moreover, there is a substantial space between the location where large clamping forces are applied by the hydrostatic pads, and the periphery of the grinding wheels.

[0008] Sheet five (Stress-Distribution: Original Hydrostatic-Pad) is a visual illustration of the stress distribution on the wafer for the conventional (or "original") hydrostatic pads. The representation in the upper left corner shows the distribution resulting from shift of the grinding wheels (i.e., translation along the axis of rotation of the wheels). The upper right representation shows the stress distribution for shift and vertical tilt (i.e., tilting of the grinding wheels about a horizontal axis passing at a right angle through the axis of rotation of the grinding wheels). The lower left hand pictures the stress distribution for a combination of shift and horizontal tilt (i.e., tilting of the grinding wheels about a vertical axis passing at a right angle through the axis of rotation of the wheels). The lower right-hand picture shows stress distribution with a combination of shift, vertical tilt and horizontal tilt. It is noted that yellow indicates extremely high stresses. The location of high stress in the wafer is also located near to the periphery of the grinding wheels. Stress distributions for the new hydrostatic pads (Stress-Distribution: Conceptual New Hydrostatic-Pad) are shown in sheet six. The four representations appearing are for the same movements of the clamping plane of the grinding wheels relative to the clamping plane of the hydrostatic pads illustrated in sheet

five. It may be seen that the stresses are in general lower than those found with the original pad design. Moreover, there is a larger region between concentrations of stress at a boundary where the wafer in contact with the periphery of the grinding wheel and concentrations of stress where the wafer is opposed and held by the hydrostatic pad.

[0009] Sheet seven illustrates node paths generally along the circumference of the grinding wheels. The inner node path is pink, the middle node path is orange and the outer node path is green. Sheet eight is a graphical representation of the stress in the wafer along the outer (green) node path when the wafer is subjected to stresses caused solely by a shift of the grinding wheels (i.e., without any tilt of the grinding wheels) which causes the clamping plane of the grinding wheels to diverge from the clamping plane of the hydrostatic pads. It is noted that the stresses are more nearly constant along the peripheral edge margin, even at the center of the wafer (corresponding to the middle of the node path). Sheet nine illustrates the stress along the outer node path when shift is accompanied by vertical tilt. There is a markedly less increase in stress at a location along the path corresponding to the center of the wafer with the new, redesigned pad.

[0010] Sheet ten is an illustration of stress along the outer node path as a result of shift in combination with horizontal tilt. The stress at one side of the grinding wheel (i.e., the left side) does not increase as sharply with the new design. This corresponds to a reduction in the B-ring feature formed on the wafer. Sheet eleven shows distribution of stress along the outer node under the combined effect of shift, vertical tilt and horizontal tilt. Again, large differential in stress are not found along the node.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a pictorial representation of a surface of a wafer ground according to the prior art, polished and analyzed for nanotopology surface features, and also a graphical representation of the radial profile of the one surface of the wafer;

[0012] FIG. 2 is a schematic illustration of the grinding wheels showing tilt of the grinding wheels;

[0013] FIG. 3 is a schematic illustration of fragments of a semiconductor wafer, grinding wheels and hydrostatic pads near the top center of the grinding wheels when the grinding wheels shift and are subject to vertical tilt in a grinder with a conventional hydrostatic pad design. It may be seen that the (gray) wafer is bent sharply between the periphery of the grinding wheels and the adjacent (lower) edge of the hydrostatic pads. This causes warp which produces a center mark evident in the nanotopology of the finished wafer (Fig. 1);

[0014] FIG. 4 includes comparative schematic illustrations of the conventional ("original") grinder with the grinder of the present invention having the new hydrostatic pads. The view on the top left shows the arrangement (as viewed from the front) of the grinding wheel (green), the hydrostatic pad (blue) and the wafer (gray, but mostly covered by the wheel and pad). The view on the lower left is substantially the same as Fig. 3. The view on the upper right schematically illustrates the new hydrostatic pad having an opening for receiving the grinding wheel which does not conform precisely to the shape of the perimeter of the grinding wheel. Although the opening appears asymmetric about the grinding wheel, the opening would most likely have the same, symmetric but non-conformal shape about the grinding wheel. The lower right-hand view shows how separation of the clamping of the hydrostatic pad from the grinding wheel allows for a gentler bend of the wafer between the two as a result of shift and tilt of the grinding wheels. In other words, the

wafer is more free to conform to the new clamping plane defined by the displaced grinding wheels;

[0015] FIG. 5 contains views of the face of one of the hydrostatic pads which opposes the surface of the wafer. The view on the left (current design) shows the existing shape and arrangement of pockets. The view on the right (proposed new design) shows one possible configuration of pockets. The views also illustrate that the reconfiguration of the pockets from the current to the proposed new design brings the center of clamping of the hydrostatic pads closer to the center of the wheels;

[0016] FIG. 6 is an elevation of a face of a conventional hydrostatic pad showing the configuration of the face which opposes the wafer in use;

[0017] FIG. 7 is an elevation of a face of a new hydrostatic pad showing the configuration of the face which opposes the wafer in use; and

[0018] FIG. 8 is an elevation of a face of a second new hydrostatic pad showing the configuration of the face which opposes the wafer in use.

BRIEF DESCRIPTION OF THE INVENTION

[0019] The present invention is directed to hydrostatic pads that hold the wafer less rigidly in the clamping plane of the pads, thereby allowing the wafer greater ability to conform to the clamping plane of the grinding wheels in operation of the grinder. Accordingly, warp and nanotopology features such as center marks and B-rings (Fig. 1) are reduced. One modification is to increase the separation between the edge of the hydrostatic pad and the adjacent peripheral edge of the grinding wheel. The conventional hydrostatic pads provide a substantially uniform spacing between the edges on the order of 3 mm. The present invention increases the spacing in certain locations up to about 20 mm (see Fig. 4). Instead of having the same, substantially circular shape as the portion of the grinding wheel aligned with the pad opening,

the pad opening has a shape which does not conform exactly to the shape of the perimeter of the grinding wheel. More particularly, the pad opening curves away from the perimeter of the grinding wheels at the top and on opposite sides of the grinding wheels. These are the locations where maximum stress can be applied to the wafer as a result of shift of the grinding wheels in combination with vertical and/or horizontal tilt.

[0020] As discussed previously, large localized stresses are applied at the center of the wafer in conditions where the grinding wheel clamping plane shifts (i.e., along the rotation axis of the grinding wheels) and the wheels are subject to vertical tilt (Fig. 3). By separating the periphery of the grinding wheels from the adjacent edge of the hydrostatic pad, the bend which is produced in the wafer is more gradual (see Fig. 4, lower right), and not sharp as found with the original hydrostatic pad (see Fig. 4, lower left). The wafer is given a greater degree of freedom by the new hydrostatic pads to conform to the clamping plane of the grinding wheels. As a result, it is believed that warp, and more particularly center marks are reduced, improving the nanotopology of the finished wafer. Similarly, large localized stresses can also be applied to the wafer on either side of the grinding wheels when the grinding wheel shifts and the wheels are subject to horizontal tilt. The separation of the adjacent edge of the hydrostatic pad from the perimeter of the grinding wheel at these locations also permits more conformance of the wafer to the clamping plane of the grinding wheels so that stresses and ultimately warp and B-ring formation are attenuated.

[0021] Referring to Fig. 5, another modification to the existing hydrostatic pads pertains to the number, shape and arrangement of pockets on the face of each pad which opposes the wafer surface. A more accurate (not schematic) representation of the face of a conventional hydrostatic pad is shown in Fig. 6 of the drawings. A less schematic

representation of a new hydrostatic pad design is shown in Fig. 7. Figure 8 is a view of a second new hydrostatic pad. The view is more schematic and omits the water orifices which would be present in the pockets. The total area of the pockets on the faces of the new hydrostatic pads is reduced. The number of pockets could also be reduced (see Fig. 5). It is believed that it is not necessary to clamp the wafer so tightly to hold it in place during grinding, allowing the wafer a greater freedom to conform to the clamping plane of the grinding wheels. In addition, the pockets have been shaped so that the center of clamping (i.e., the point where the clamping force is effectively applied by the hydrostatic pads) moves close to the center of the grinding wheels (where the clamping force of the grinding wheels is effectively applied). The shaping involves moving the area of the pockets somewhat downward on the face of the pad, thereby moving the center of clamping down toward the center of the grinding wheels. The center of the grinding wheels lies substantially on the axis of rotation of the wheels along which the wheels may move ("shift"). The more nearly coincident the center of clamping and center of the grinding wheels, the more uniform the application of stress to the wafer around the circumference of the grinding wheels as a result of shift of the grinding wheels. On the contrary where the center of the grinding wheels and center of clamping are spaced farther apart, shift of the grinding wheels results in a bending moment caused by the radial separation of the center of clamping of the hydrostatic pads and the center of the grinding wheels which produces concentration of pressure and stress in localized regions. One of these regions is at the center of the wafer. If the effect of shift of the grinding wheels can be neutralized (or more nearly neutralized) as a cause of warp, then calibration of the grinder to control tilt (both vertical and horizontal) of the grinding wheels produces wafers free of pronounced center marks and B-rings.

[0022] It is also contemplated that the clamping force applied by the hydrostatic pads, and center of clamping location relative to the center of the grinding wheels could be affected by controlling the pressure of the water applied to the pockets of the hydrostatic pads. More particularly, the fluid pressure in each pocket (or some subset of pockets) could be changed during the course of grinding and/or controlled independently of the other pocket(s). One way of varying the pressure among the several pockets is by making the sizes of the orifices opening into the pockets different. However, it is also contemplated that all of the pockets can have the same water pressure applied to them. Moreover, the stiffness of the region associated with each pocket can be varied among the pockets by making the depth of the pockets different. Deeper pockets will result in a more compliant hold on the wafer in the region of the deeper pocket than shallower pockets, which will hold the wafer stiffly in the region of the shallower pocket.

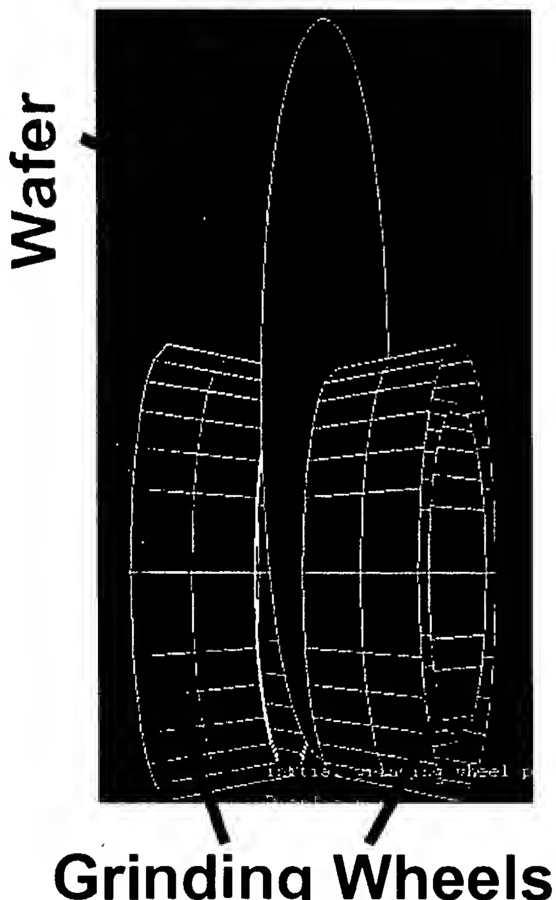
[0023] When introducing elements of the present invention or the preferred embodiment(s) thereof, the articles "a", "an", "the" and "said" are intended to mean that there are one or more of the elements. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0024] As various changes could be made in the above without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Double-Sided Grinding (DSG)
- Finite Element Analysis (FEA) Using MARC -

Objective: Improved hydrostatic-pad design for DSG

FE Model



Material Properties

$E = 1.27 \times 10^8$ kg/mm/s^2, $\nu = 0.2$

Contact Physics

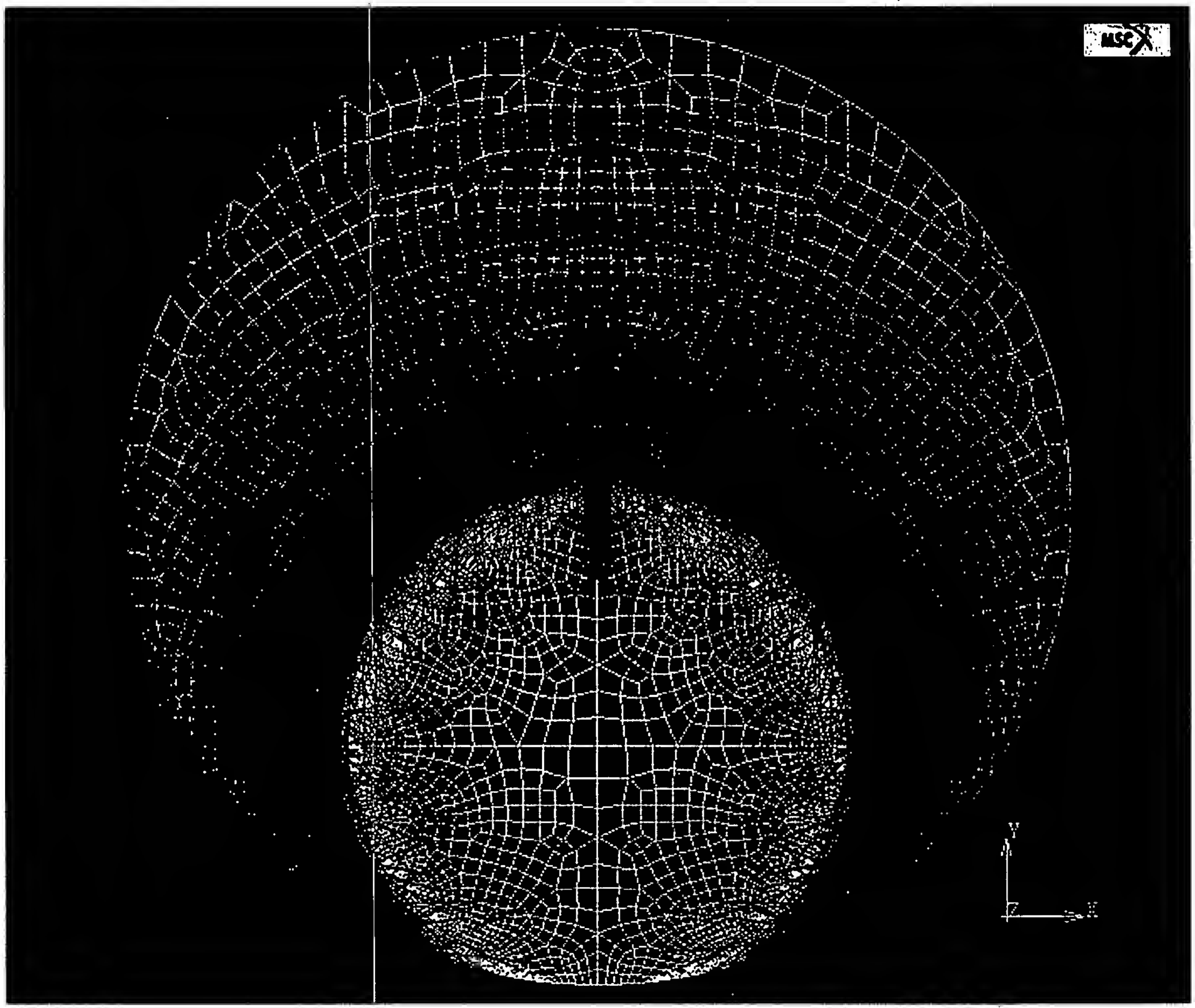
Grinding Wheels:
- **Treated as rigid bodies**
- **Prescribed linear motion**
- **No rotation**

Wafer:
- **Deformable**
- **Hydrostatic Pad simulated as face foundation (k=1000 N/mm)**
- **No rotation**

Process Conditions

Shift = 5mm, Hor./Vert. Tilts of 2.5°

Original Pad: Spatially Uniform Clamping



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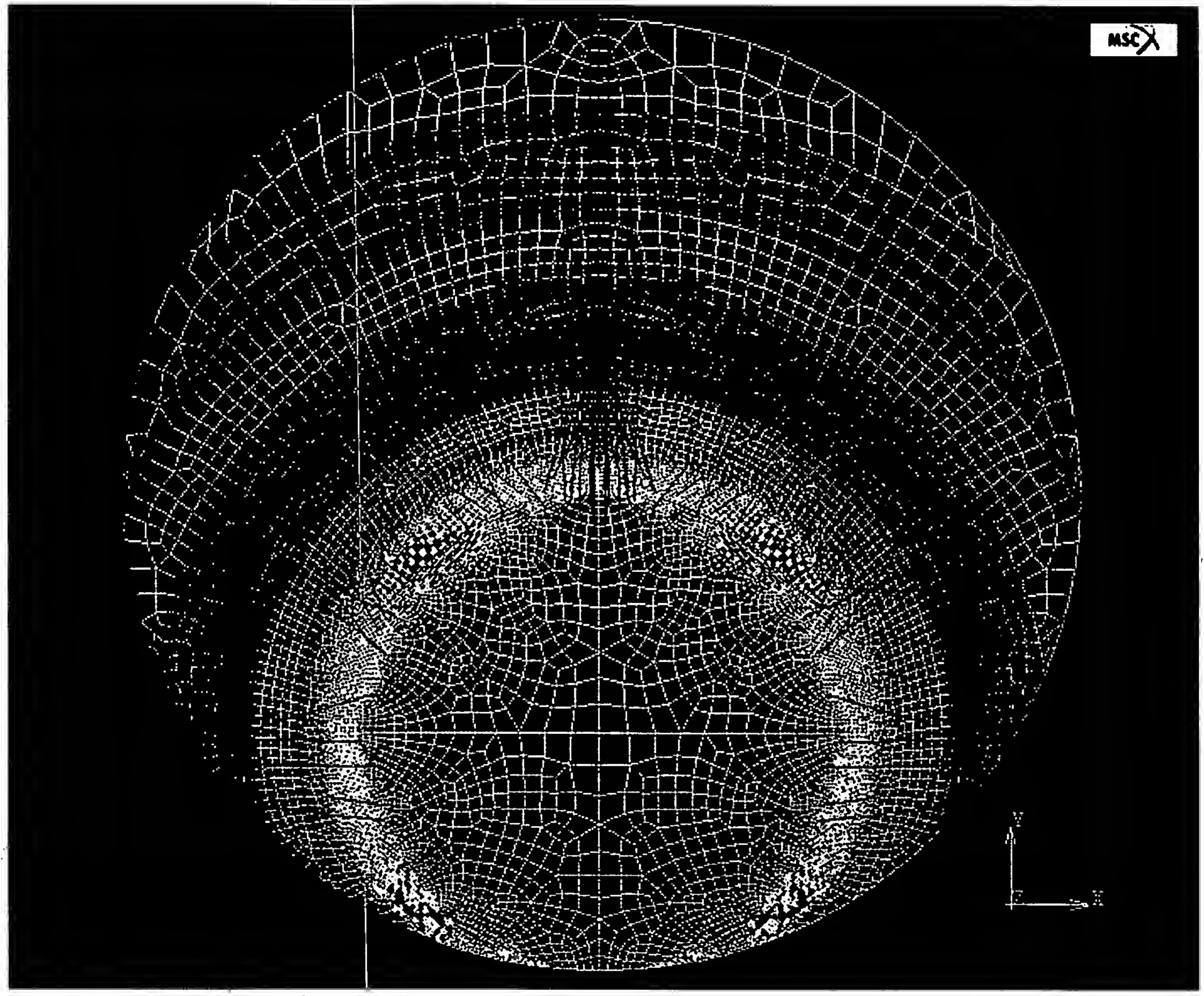
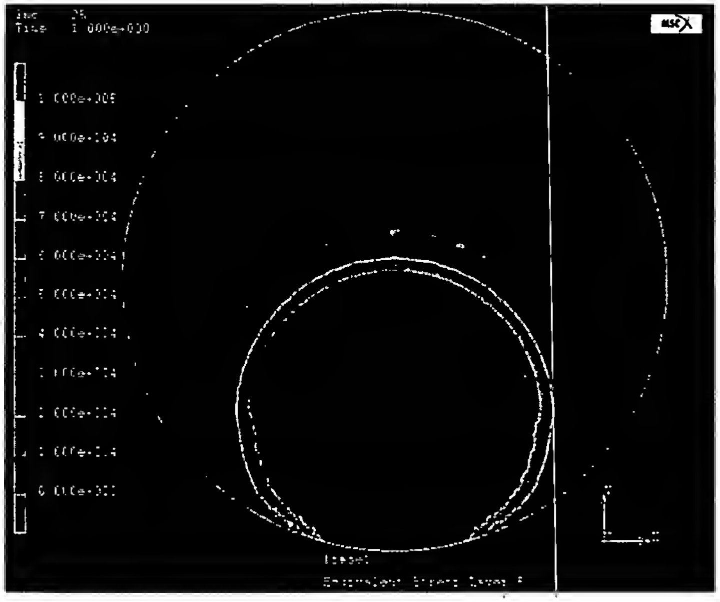
New Pad: Spatially Non-Uniform Clamping

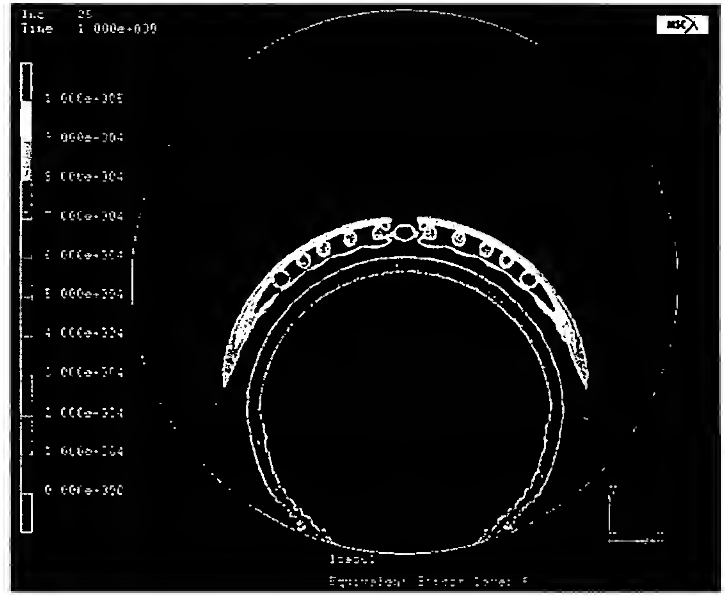


Stress-Distribution: Original Hydrostatic-Pad

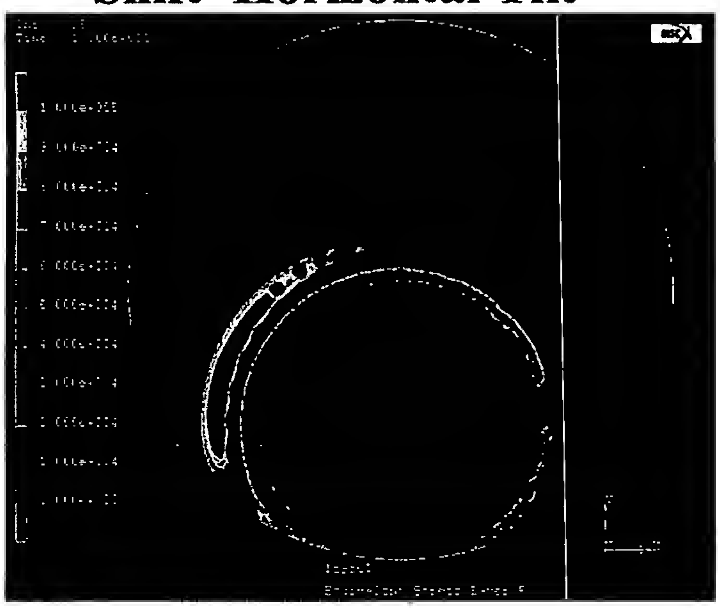
Shift



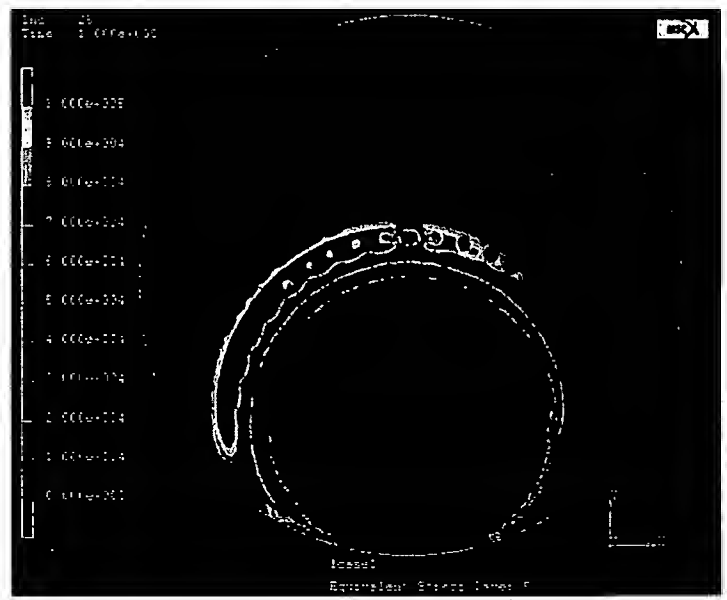
Shift + Vertical Tilt



Shift+Horizontal Tilt



Shift+Vertical and Horizontal Tilts



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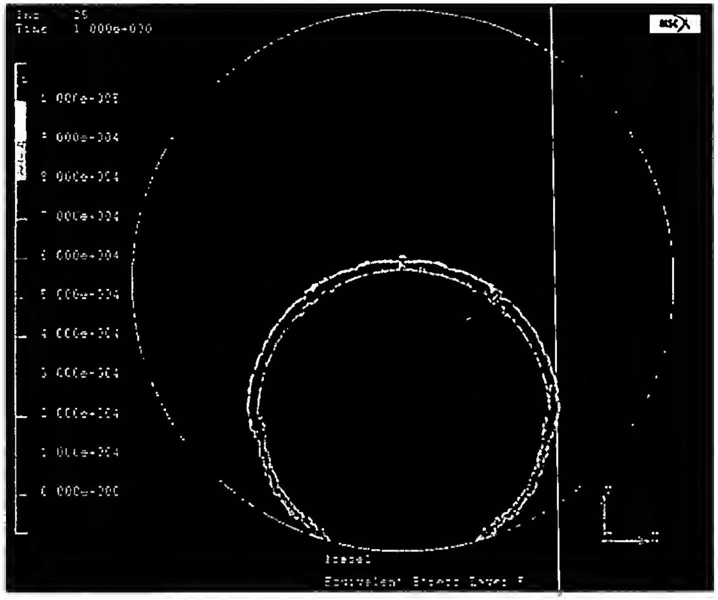
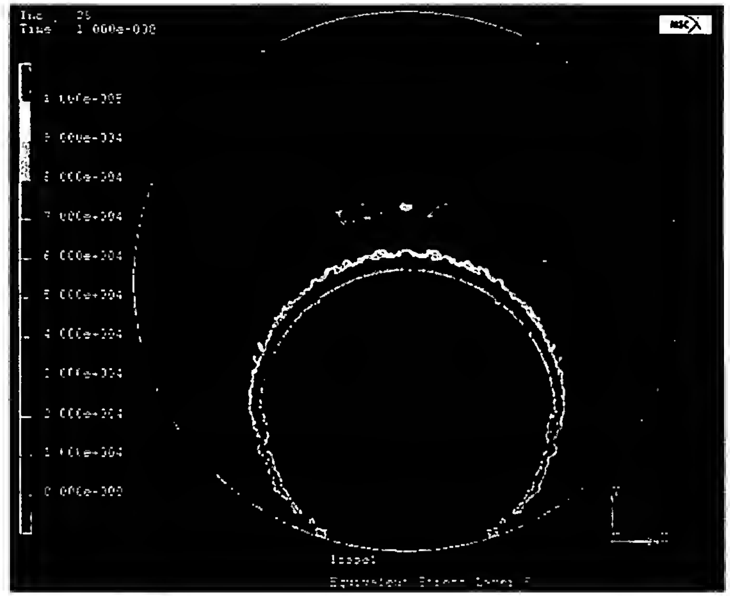
Stress-Distribution: Conceptual New Hydrostatic-Pad

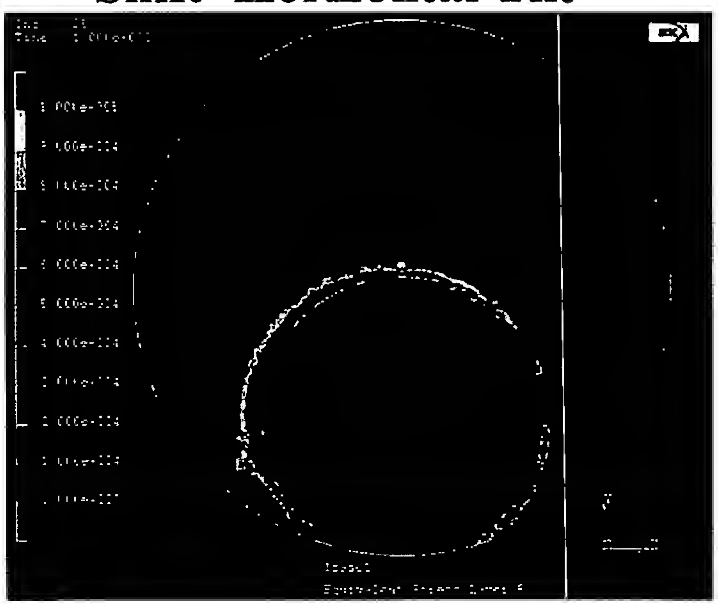
Shift



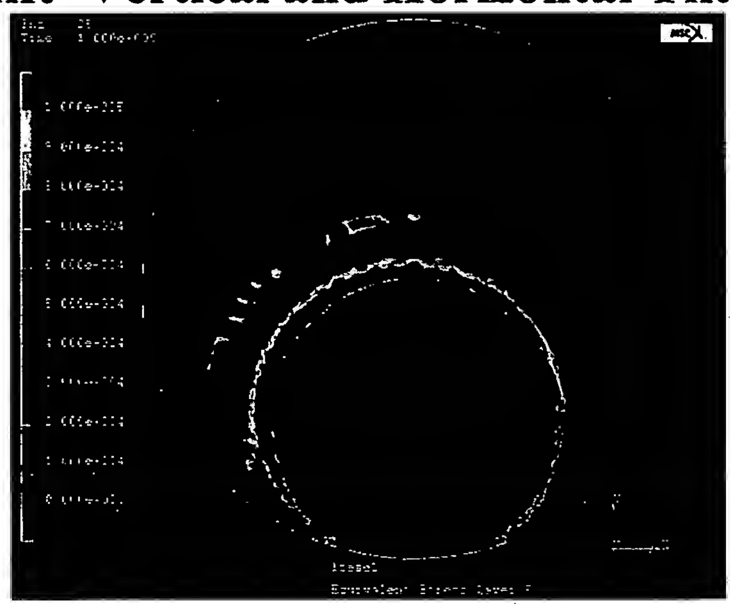
Shift + Vertical Tilt



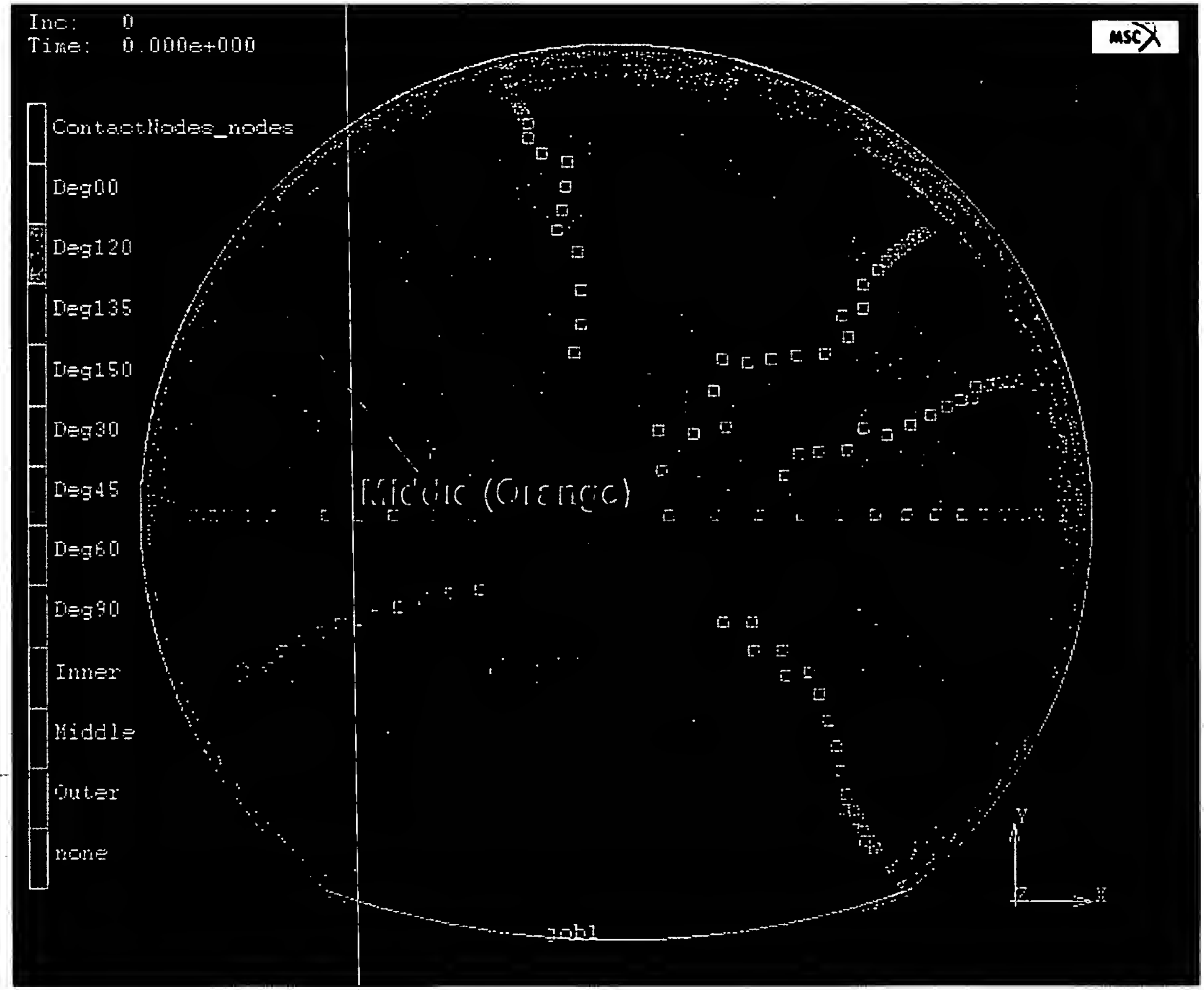
Shift+Horizontal Tilt



Shift+Vertical and Horizontal Tilts



Node Paths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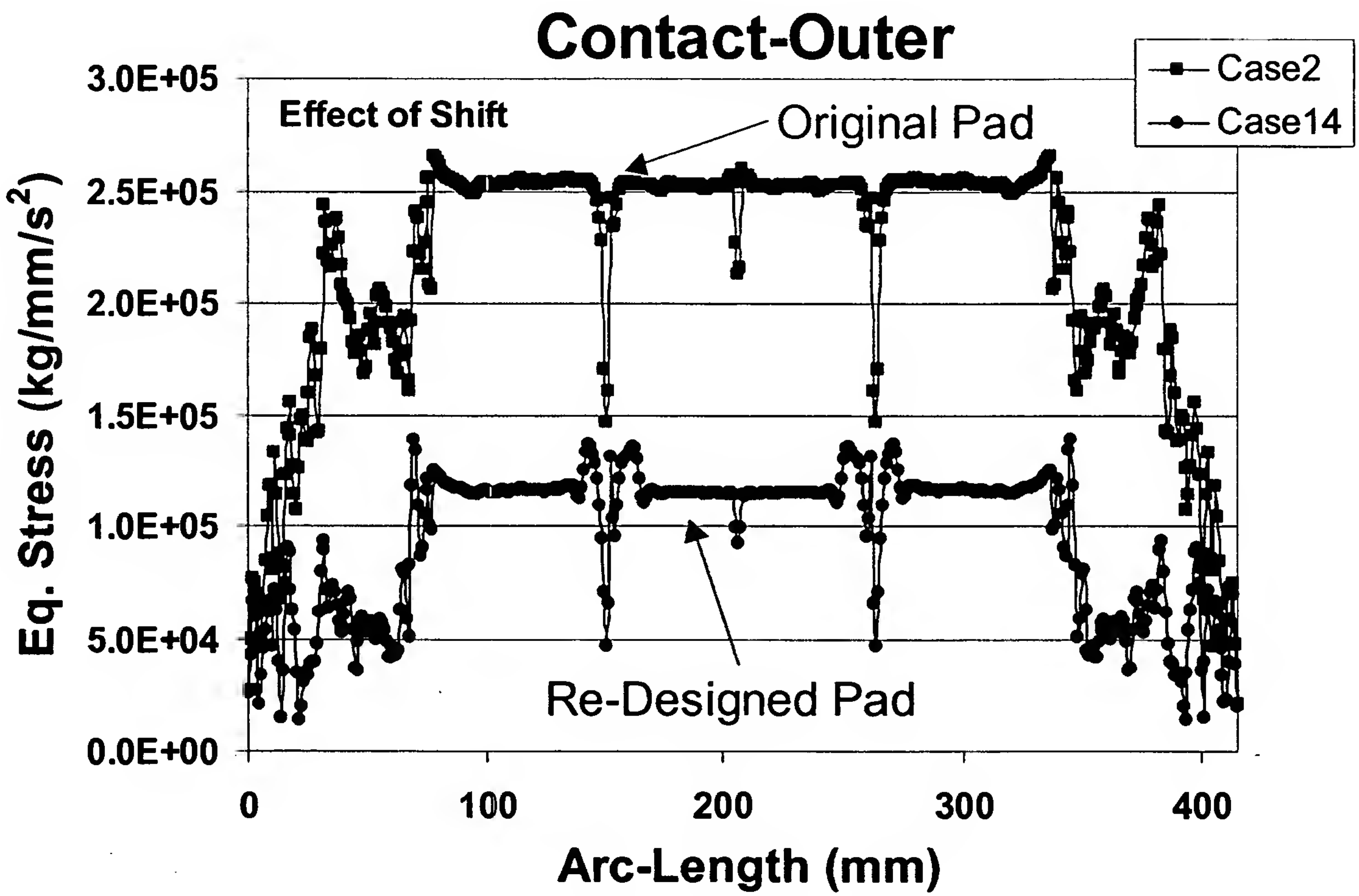
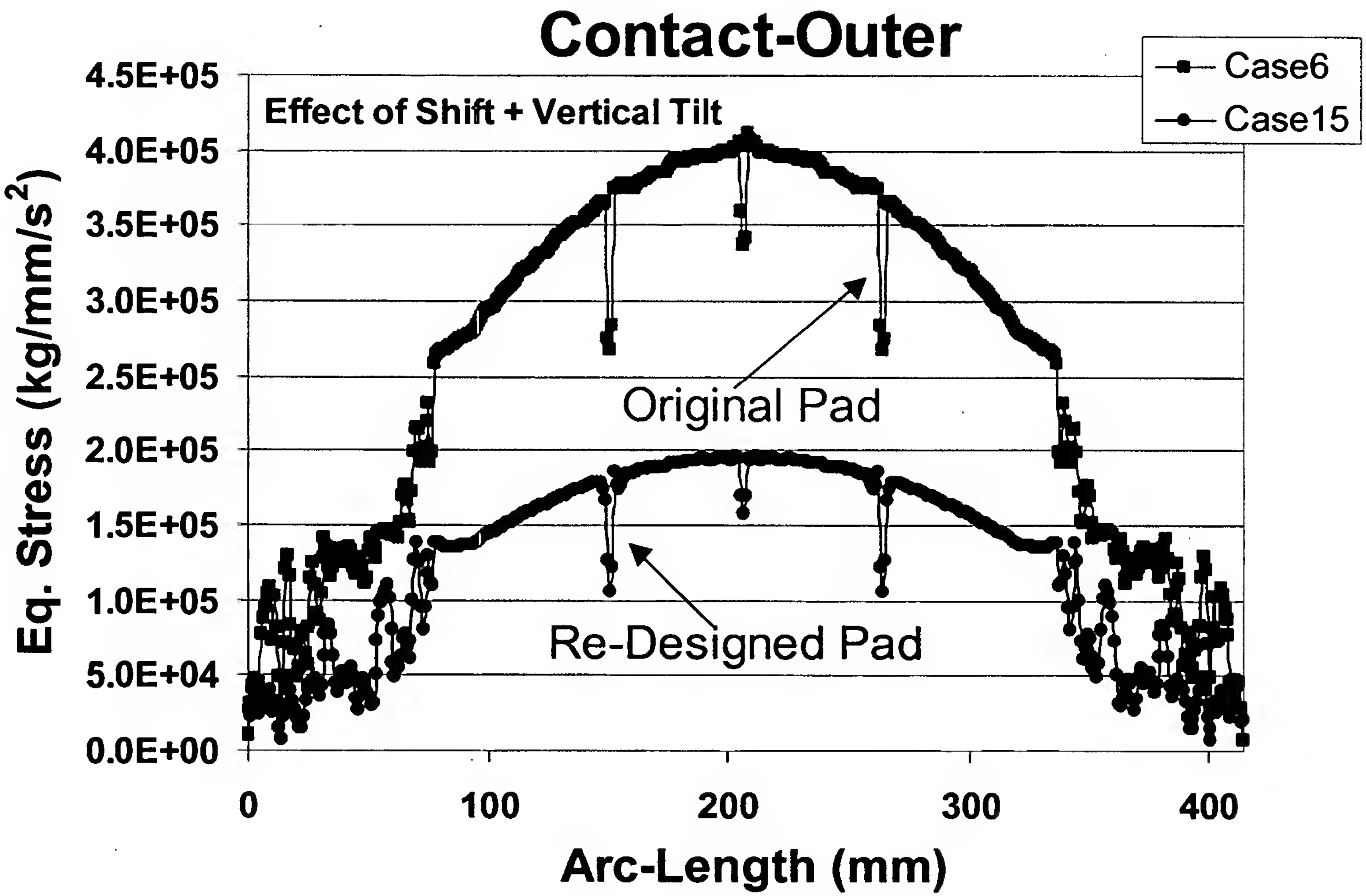
Time: 0.000e+000
ContactNodes_nodes
Deg00
Deg120
Deg135
Deg150
Deg30
Deg45
Deg60
Deg90
Inner
Middle
Outer
none
Middle (Orange)
job1
MSC

Stress-Profiles: Effect of Shift



Stress-Profiles: Combined Effect of Shift & Vertical Tilt



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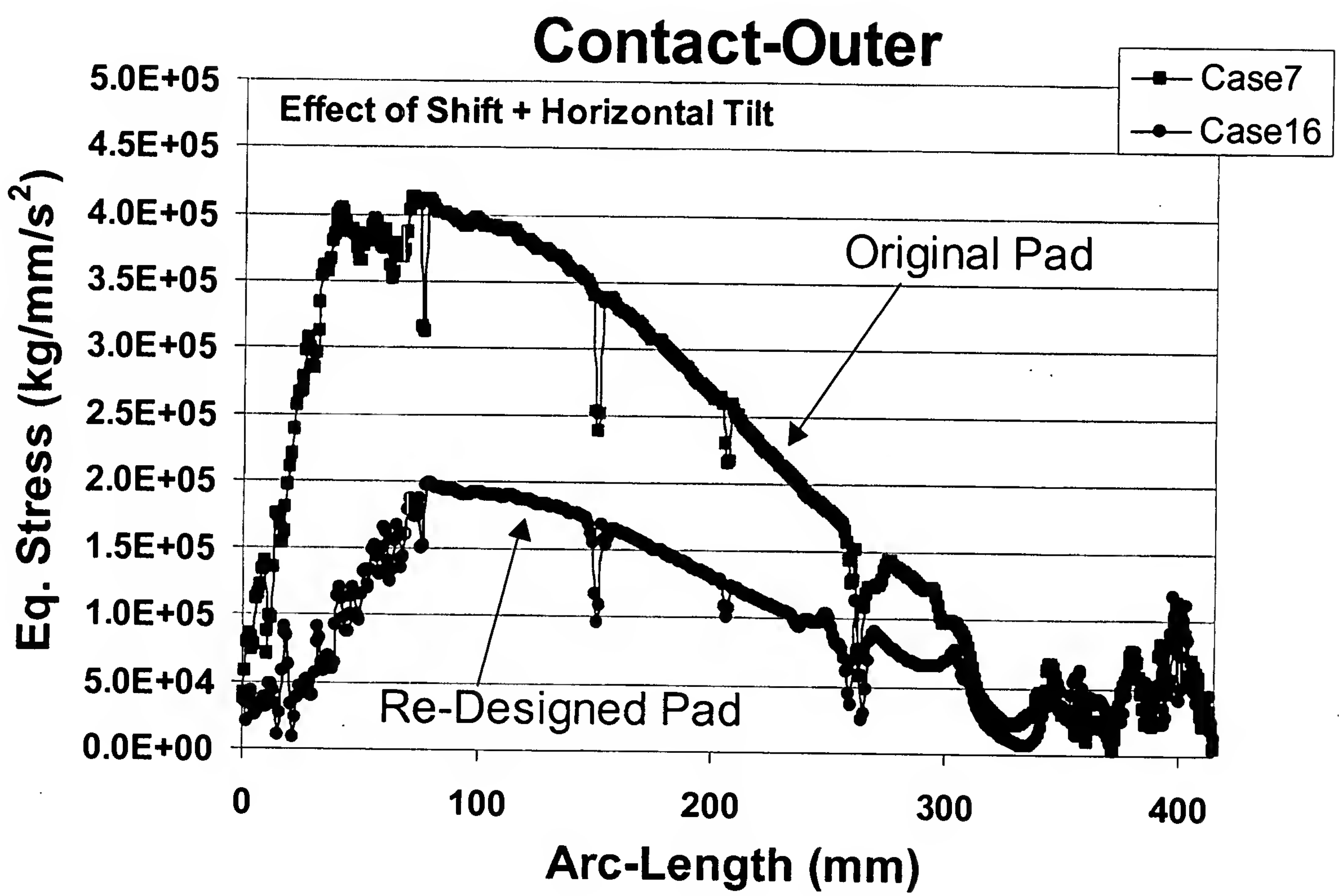
Stress-Profiles: Combined Effect of Shift & Horizontal Tilt



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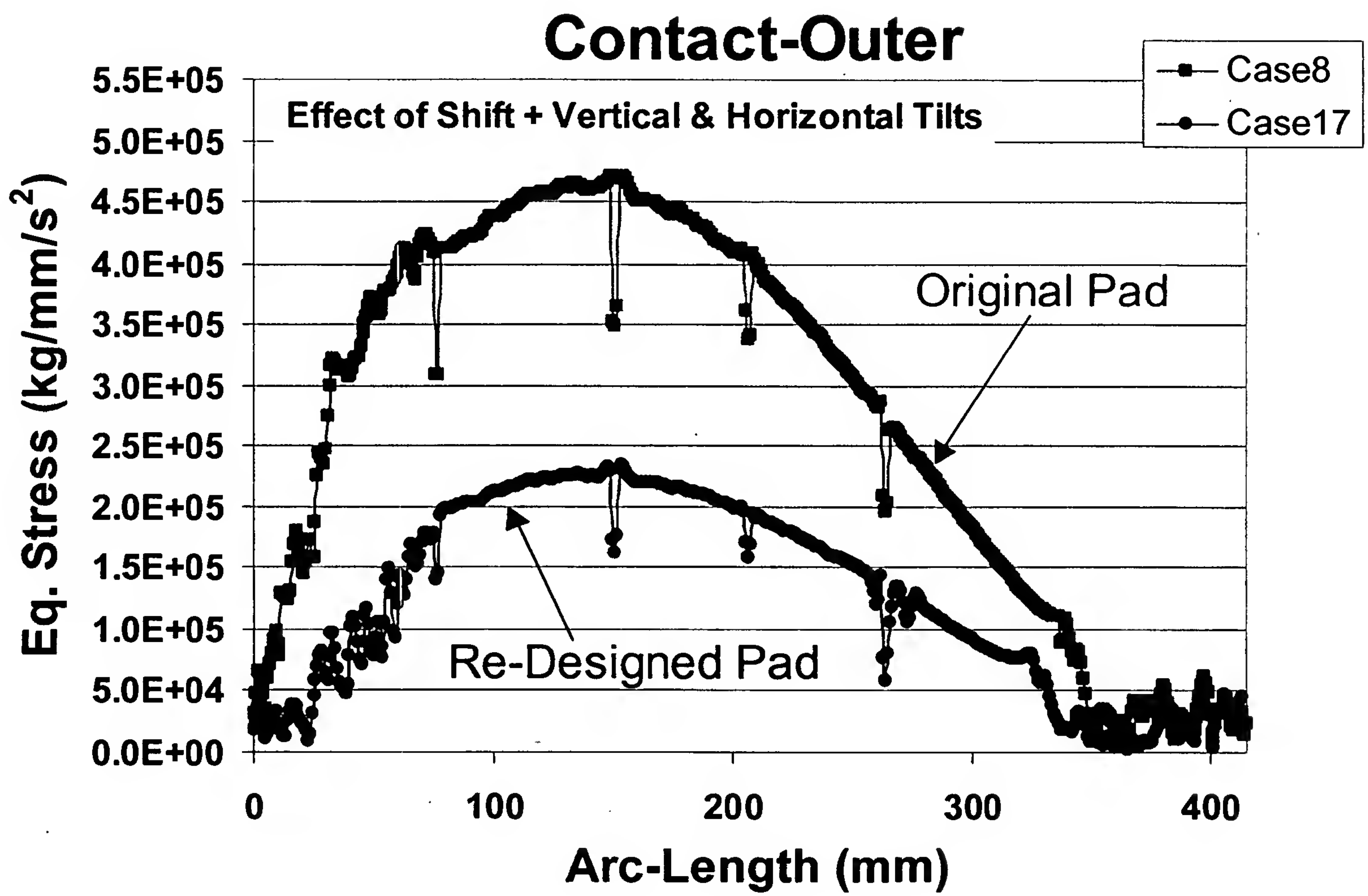
Stress-Profiles: Combined Effect of Shift & Both Tilts



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IN THE CLAIMS

1. A hydrostatic pad for use in holding a workpiece during grinding of the workpiece by grinding wheels, the hydrostatic pad including a body having an opening for receiving the grinding wheel therethrough into engagement with the workpiece held with by the pad, the opening having a shape which does not conform to the shape of the periphery of the grinding wheel whereby when the grinding wheel is received in the pad opening, the distance between the grinding wheel and a radially opposite edge of the pad opening varies around the periphery of the grinding wheel.

2. A hydrostatic pad as set forth in claim 1 in combination with a second hydrostatic pad and grinding machine including the grinding wheels and mounting the pads in opposed relation to each other.

3. A hydrostatic pad for use in holding a workpiece during grinding of the workpiece by grinding wheels, the hydrostatic pad including a body having an opening for receiving the grinding wheel therethrough into engagement with the workpiece held with by the pad, the body having a face formed with at least one pocket therein and being adapted for receiving fluid through the body into the pocket for providing a sliding barrier between the body face and the workpiece, and for applying pressure to the workpiece during grinding, the pocket being shaped and arranged so that a center of clamping of the pad when used in combination with another pad is closely adjacent to the center of the grinding wheels.

APPENDIX A

The description of Figures in this Appendix refers to the drawing figures attached to this application.

Brief Statement of Invention: Some of the nanotopology features on a polished 300mm wafer can be attributed to wafer deformation during Koyo Simultaneous Double Side Grinding (SDSG). The root cause of wafer deformation in SDSG is the misalignment between the wafer clamping-plane and the grinding surface (defined jointly by the two grinding wheels). The clamping mechanism on Koyo Grinders is in form of hydrostatic pads. In this invention disclosure, we propose to change the design of hydrostatic pad so that Koyo SDSG process would be more forgiving to misalignments. Benefits of this would be improved wafer nanotopology and minimization of setup time to achieve better nanotopology.

State the problem intended to be solved, attempted solutions by others, and your solution. Give any unexpected results of your solution.

Simultaneous Double Side Grinding (SDSG) is a relatively new process used to planarize the wafers before polishing. MEMC uses Koyo SDS Grinders to planarize the 300mm wafers. SDSG technology, in its current form, produces certain features on the wafer. After polishing, these features manifest in form of nanotopology degradation. Two most common NT features attributed to SDSG are B-rings and center-marks. These features are shown in Figure [1]. The B-ring and Center-Mark features are produced in Koyo SDSG process because of misalignment between the wafer clamping plane and the grinding surface.

In Koyo SDS grinders, the hydrostatic pads define the 'wafer clamping plane'. These hydrostatic pads, one on each side

of the wafer, support the wafer while it is rotating during grinding. The 'grinding surface' is defined jointly by position of the two grinding wheels. The grinding wheels, in addition to rotating and translating about their axes, also have additional tilt degrees of freedom. They can tilt horizontally and vertically (Figure [2]). The tilts are necessary to control the TTV and surface roughness of ground wafers. The wheels wear unevenly during grinding, and as a result the grinding plane shifts. The shift and the tilts together define the grinding surface. Figure [3] shows conceptually the wafer deformation caused by misalignment of grinding surface and clamping plane.

The wafer deformation leading to center-mark, is mostly caused by shift and vertical tilt. While wafer deformation leading to B-ring is strongly influenced by shift and horizontal tilt.

One way of avoiding the wafer deformations is to set the machine configuration such that the shift is nearly zero and tilts are close to zero. This is easily said than done. Fine tuning the shifts and tilts for preventing wafer deformations is a very difficult. It has to be done every time grinding wheels are replaced. Also any change in grinding surfaces (say caused by uneven wheel wears or uneven dressing removals) will need resetting the configuration. This is time consuming and difficult because the ideal operating window is very narrow.

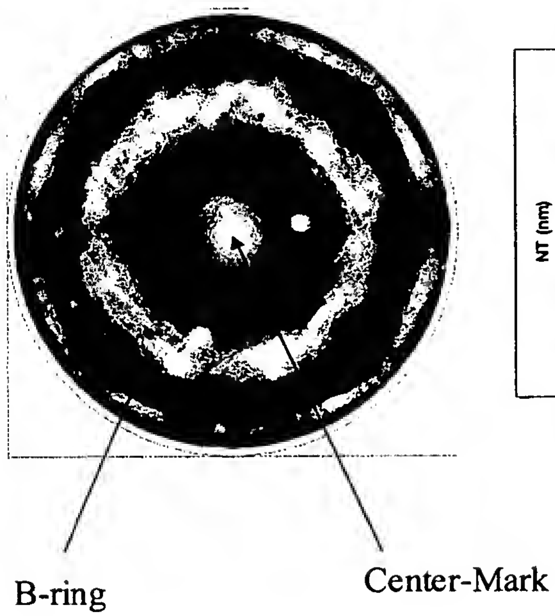
In this invention disclosure we propose measures to widen the ideal operating window of Koyo SDSG with an aim to reduce/eliminate post-polished nanotopology degradation. We do this by modifying the hydrostatic pad so that the wafer can easily conform to the grinding surface without excessive bending and stressing. This would involve:

1. Conformal Clamping: This involves reduction of sharp bending of wafer near the working surfaces of grinding wheels. This

reduces localized stiffness of wafer clamping on the grinding wheel periphery (Figure [4]).

2. Center of Clamping as Near the Center of Grinding Wheels as Possible: This involves redesign of position of hydrostatic pockets of the pad and of hydrostatic pressures inside these pockets. The aim is to reduce/eliminate the dependence of nanotopology degradation on 'shift'. The idea is that if wheel tilts are ideal, then just pure shifts should cause uniform pressure on the wafer at all points on the periphery of the grinding wheels. This makes the localized wafer stiffness uniform all over the grinding wheel periphery. (Figure [5]).

DRAWING FIGURES



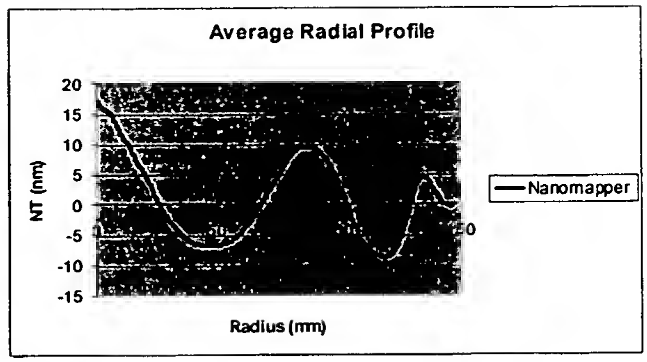


Figure [1]: Post-Polished NT Artifacts Produced by Koyo SDSG Process

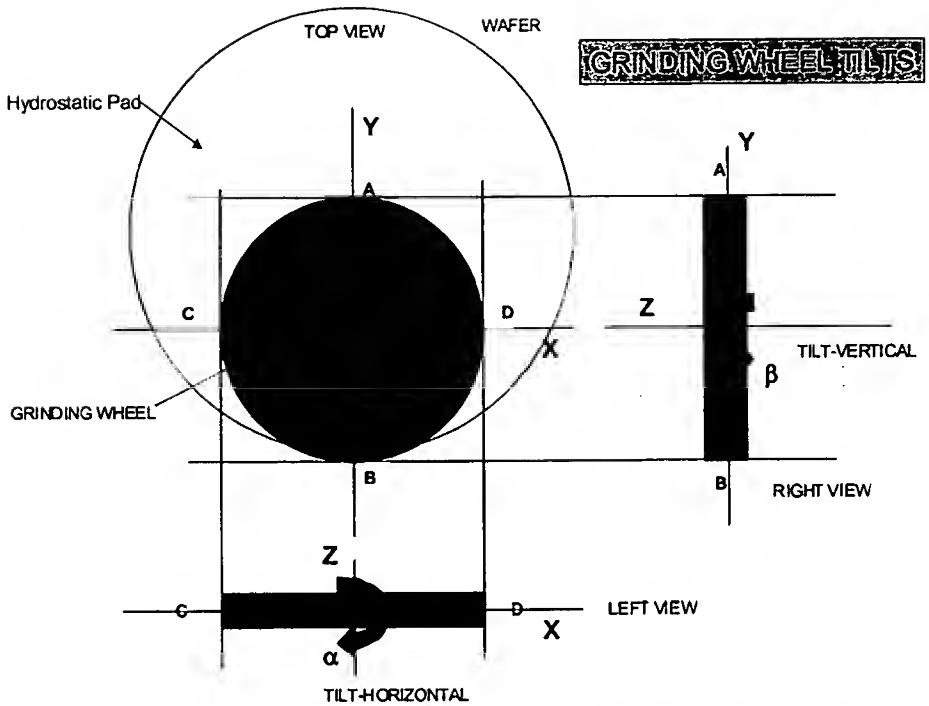


Figure [2]: Tilt Degrees of Freedom for Grinding Wheels

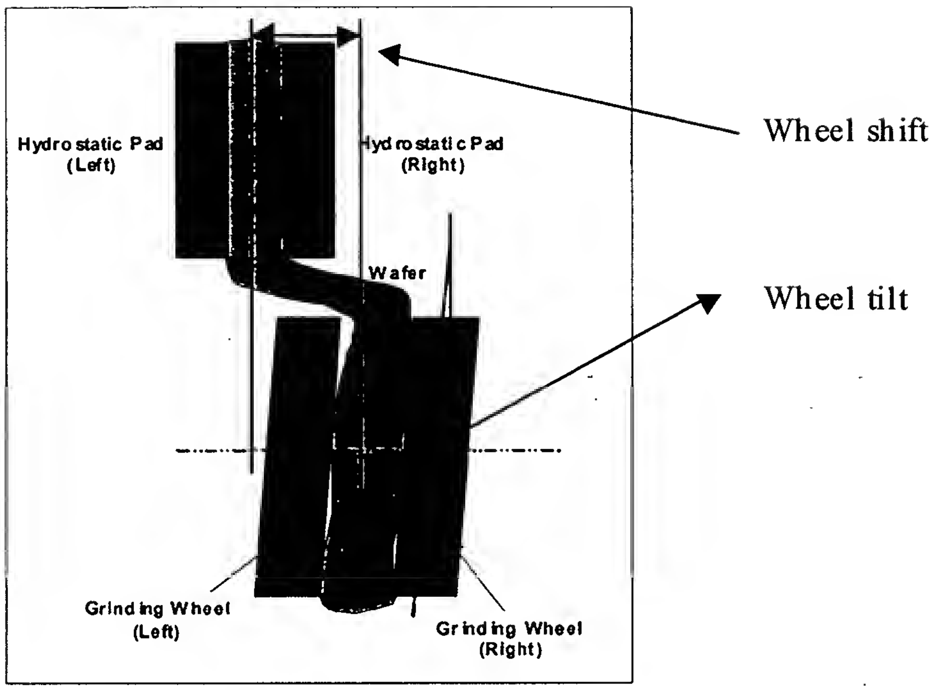


Figure [3]: Misalignment between Clamping Plane and Grinding Surface.

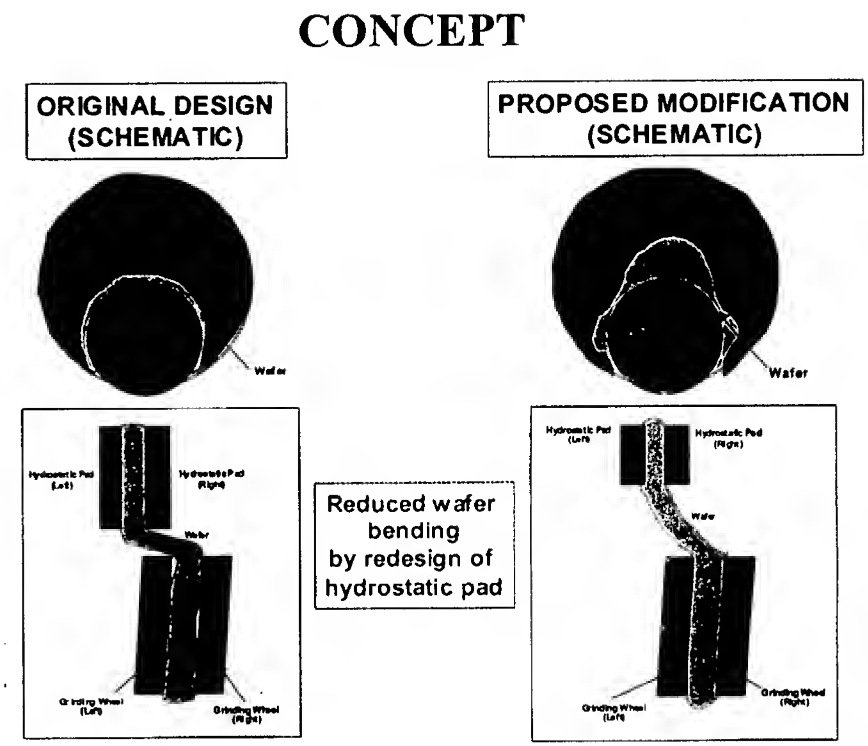


Figure [4]: Conformal Clamping (Schematic)

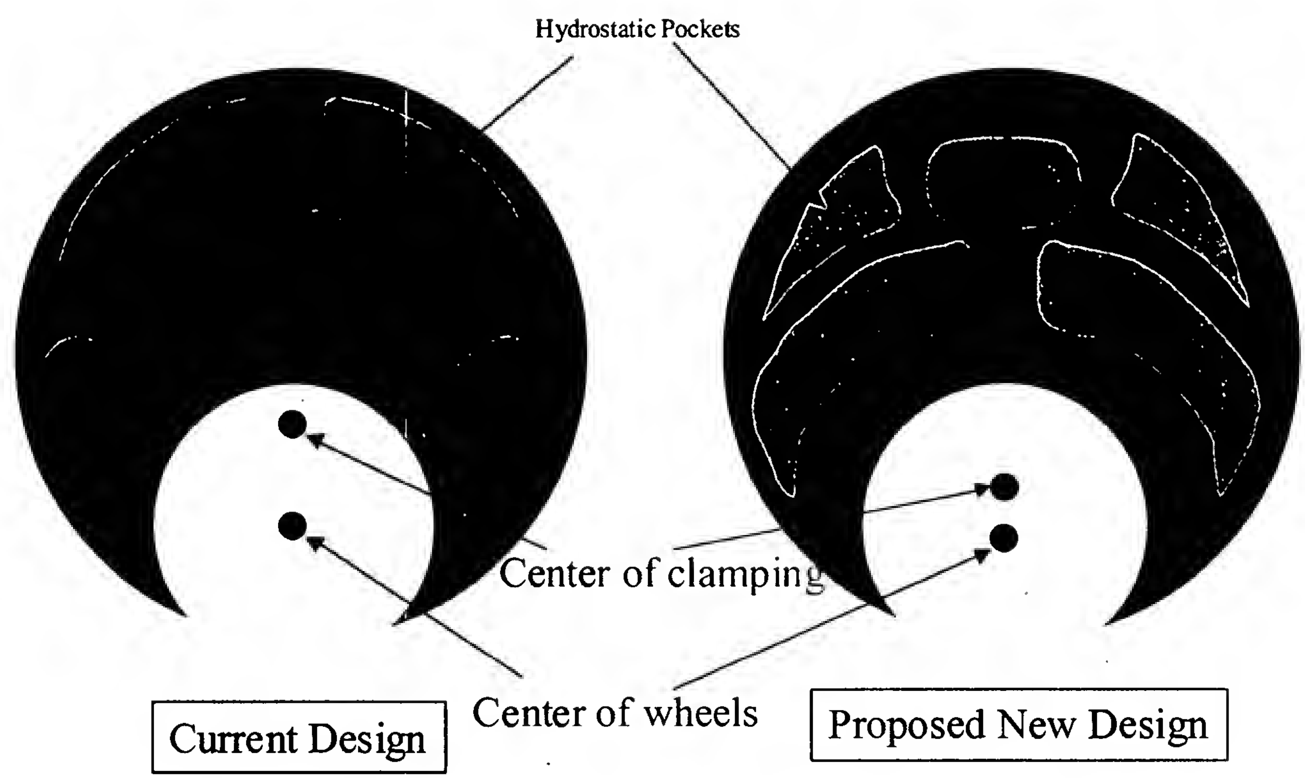


Figure [5]: Center of Clamping & Center of Grinding Wheels (Schematic)

FIG. 6

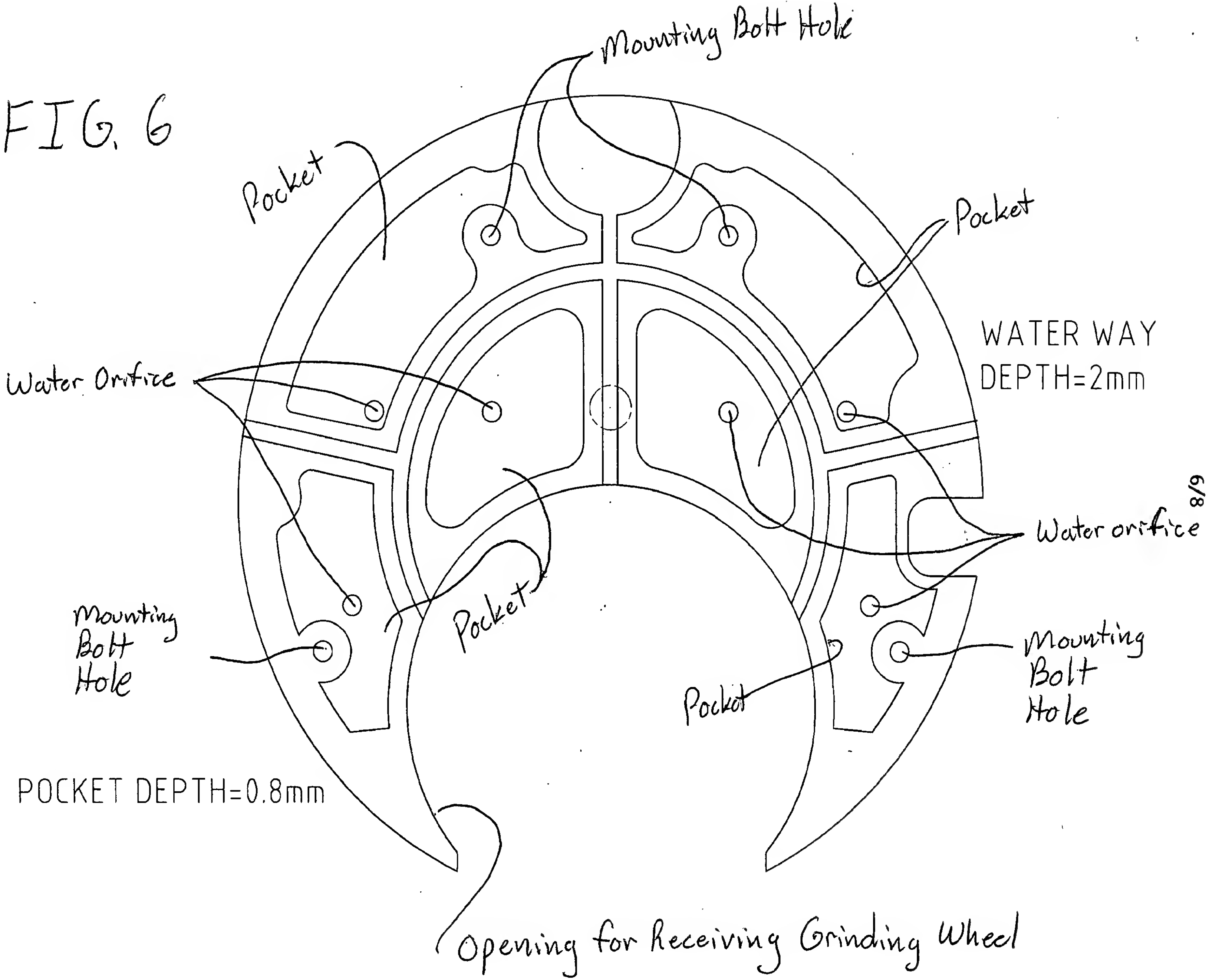

Mounting Bolt Hole
Pocket
Pocket
WATER WAY DEPTH=2mm
Water Orifice
Water orifice
Pocket
Mounting Bolt Hole
Pocket
Mounting Bolt Hole
POCKET DEPTH=0.8mm
Opening for Receiving Grinding Wheel

FIG. 7

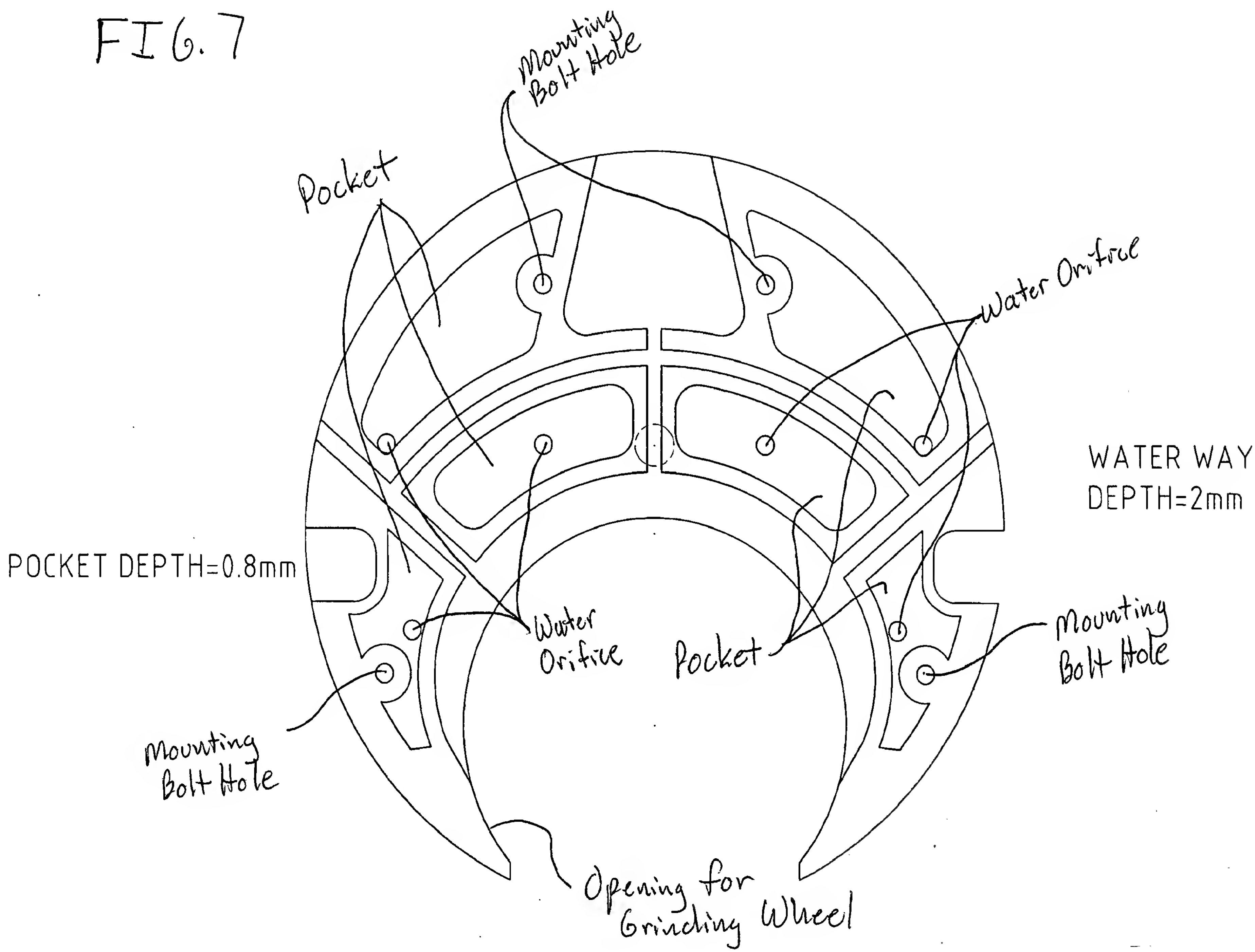
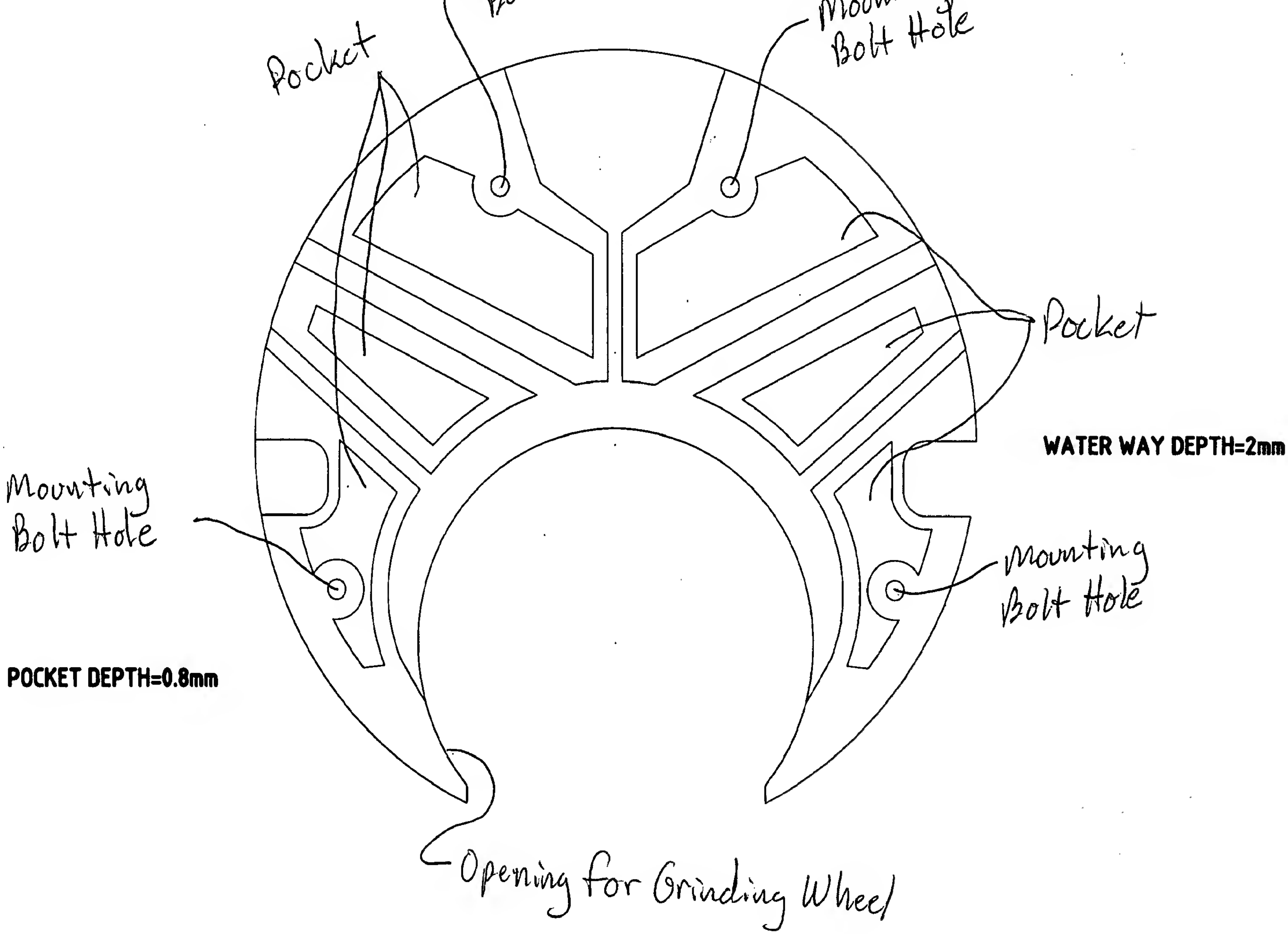

Mounting Bolt Hole
Pocket
Water Orifice
WATER WAY DEPTH=2mm
POCKET DEPTH=0.8mm
Water Orifice
Pocket
Mounting Bolt Hole
Mounting Bolt Hole
Opening for Grinding Wheel

FIG. 8


Pocket
Mounting Bolt Hole
Mounting Bolt Hole
Pocket
WATER WAY DEPTH=2mm
Mounting Bolt Hole
Mounting Bolt Hole
POCKET DEPTH=0.8mm
Opening for Grinding Wheel

APPLICATION DATA SHEET

Application Information

Application Type::	Provisional
Subject Matter::	Utility
Title::	DOUBLE SIDE GRINDER AND WAFER CLAMP DEVICE THEREFOR
Attorney Docket Number::	MEMC 04-0150 (3094)
Request for Early Publication?::	No
Request for Non-Publication?::	No
Suggested Drawing Figure::	Fig. 6
Total Drawing Sheets::	8
Small Entity?::	No
Petition Included?::	No

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